The role of Surface Pressure and SST observations in Reanalysis

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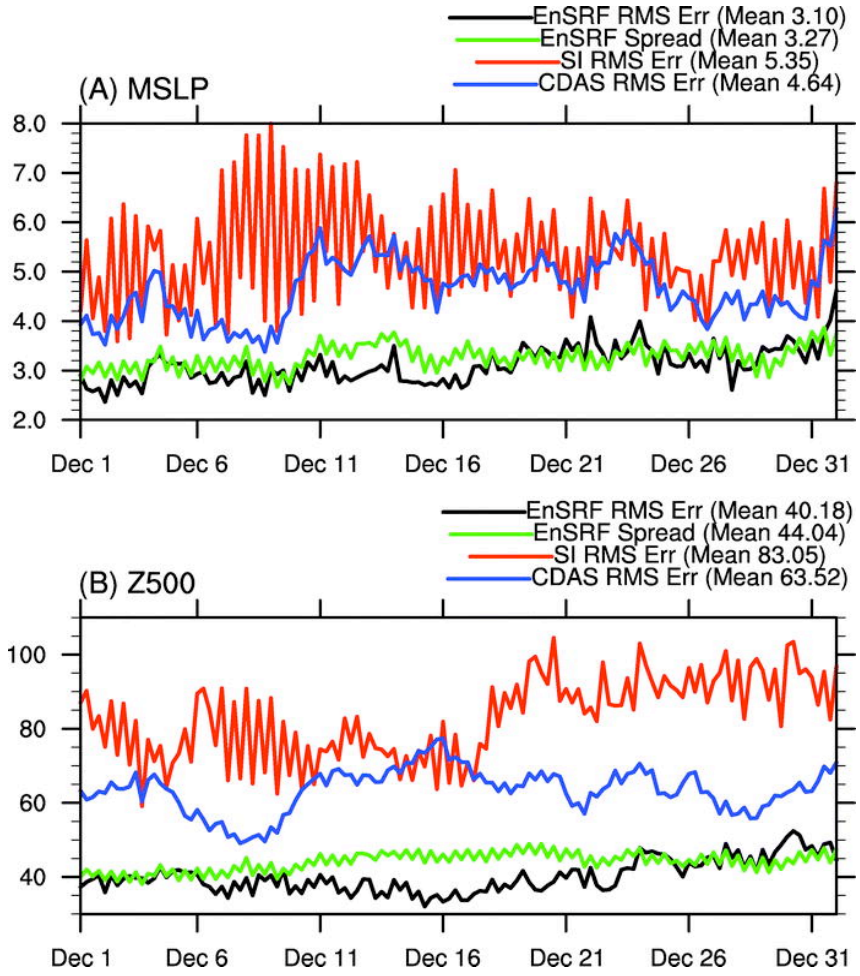
Reanalysis New Directions - 1

- Surface pressure only reanalysis pioneered by Whitaker et al (2004) using Ensemble Data Assimilation.
  - 3-dimensional atmospheric analysis may be possible back to late 1800's.

Whitaker et al. (2004)



Reanalysis New Directions - 2

- Reanalysis Observation System Simulation experiments by Bengtsson et al (2004).
  - Noted critical importance of radiosonde observation.
  - Surface only observation cannot provide good analysis.

Objective of this study

- Importance of Surface pressure and SST observations in reanalysis
  - Whitaker et al. Ps and SST used.
  - SST Usually assumed to be error free.
  - AMIP runs show that inter-annual variations can be fairly accurately simulated with SST forcing only.
- Examine the impact of SST for daily and seasonal mean analyses.
  - Does the accuracy of the analysis depend on time scale?

Experimental detail

Exp #	Name	SST	Observation data
1	CNTL	Analyzed	All observation
	CNTLC	Climatology	All observation
2	SONDE	Analyzed	Surface pressure and radiosondes
	SONDEC	Climatology	Surface pressure and radiosondes
3	PRS	Analyzed	Surface pressure only
	PRSC	Climatology	Surface pressure only
4	PRSX	Analyzed	Surface pressure only with 1915 density
	PRSXC	Climatology	Surface pressure only with 1915 density
5	AMIP	Analyzed	None
	AMIPC	Climatology	None

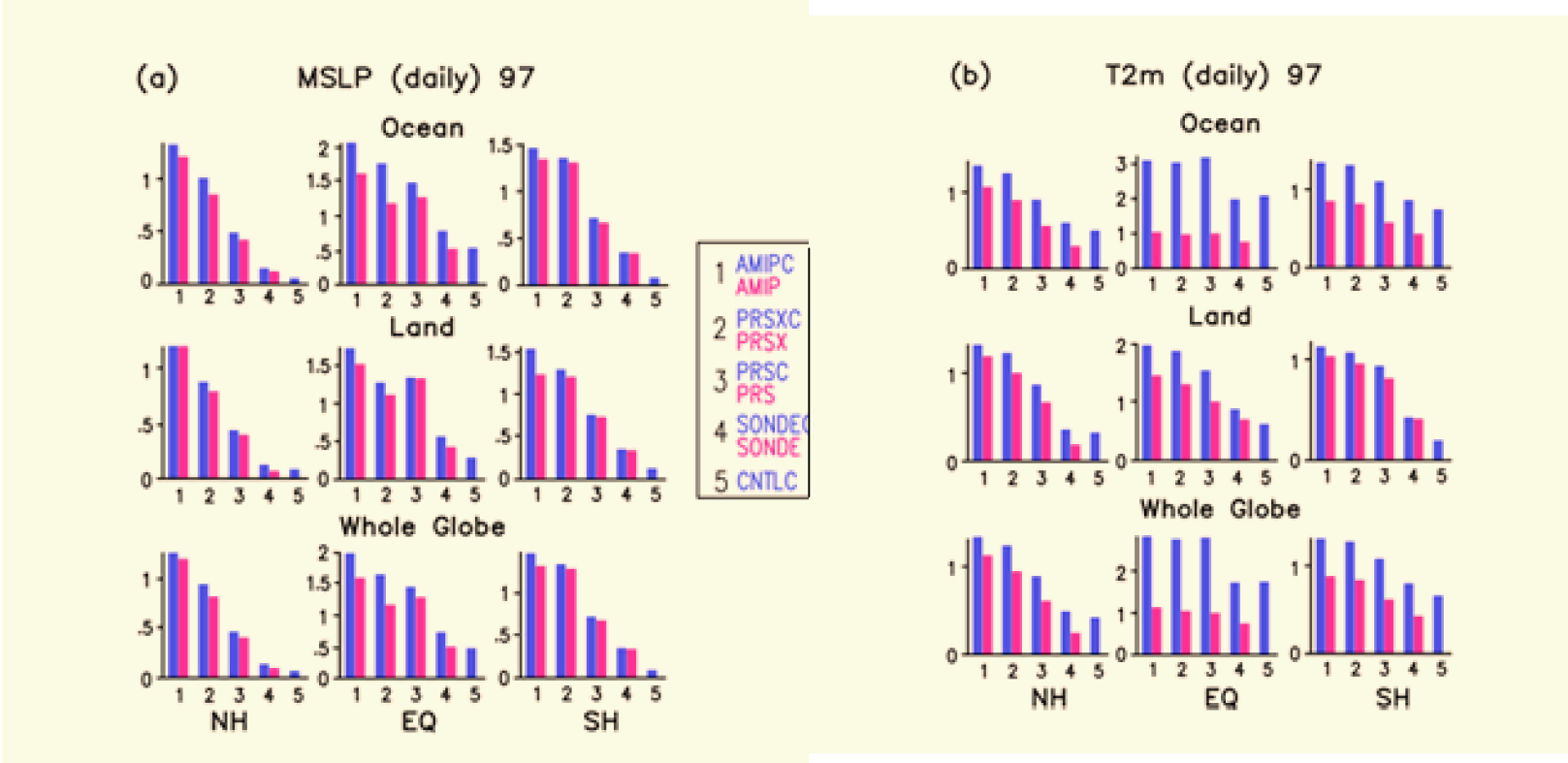
Experiment detail

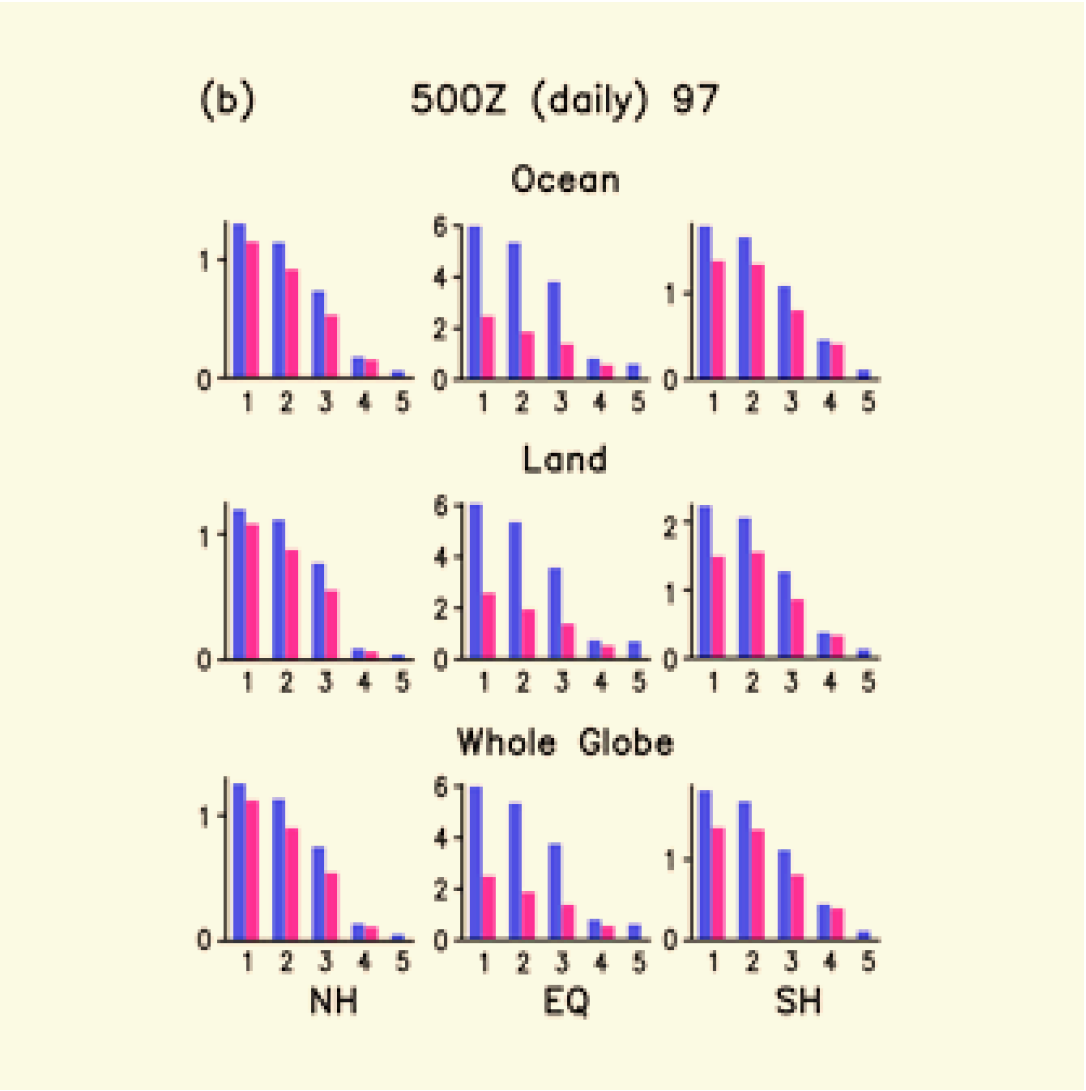
- NCEP/DOE analysis system with improved global model (3-D var)
- Independent satellite retrieval
- No surface data over land used
- No SSM/I
- Nov.1 – Feb.28 1997 and 1992
  - 1997 strong ENSO event
  - 1992 near normal SST anomaly
- Simple 5-member ensemble assimilation for surface pressure only and AMIP runs.

Results

- Assume Analysis with all the observation with observed SST is “truth”.
- Use Root Mean Square Difference as a measure of the goodness of the analysis.

Daily RMSD


(a) MSLP (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH
1 AMIPC AMIP
2 PRSXC PRSX
3 PRSC PRS
4 SONDEC SONDE
5 CNTLC
(b) T2m (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH

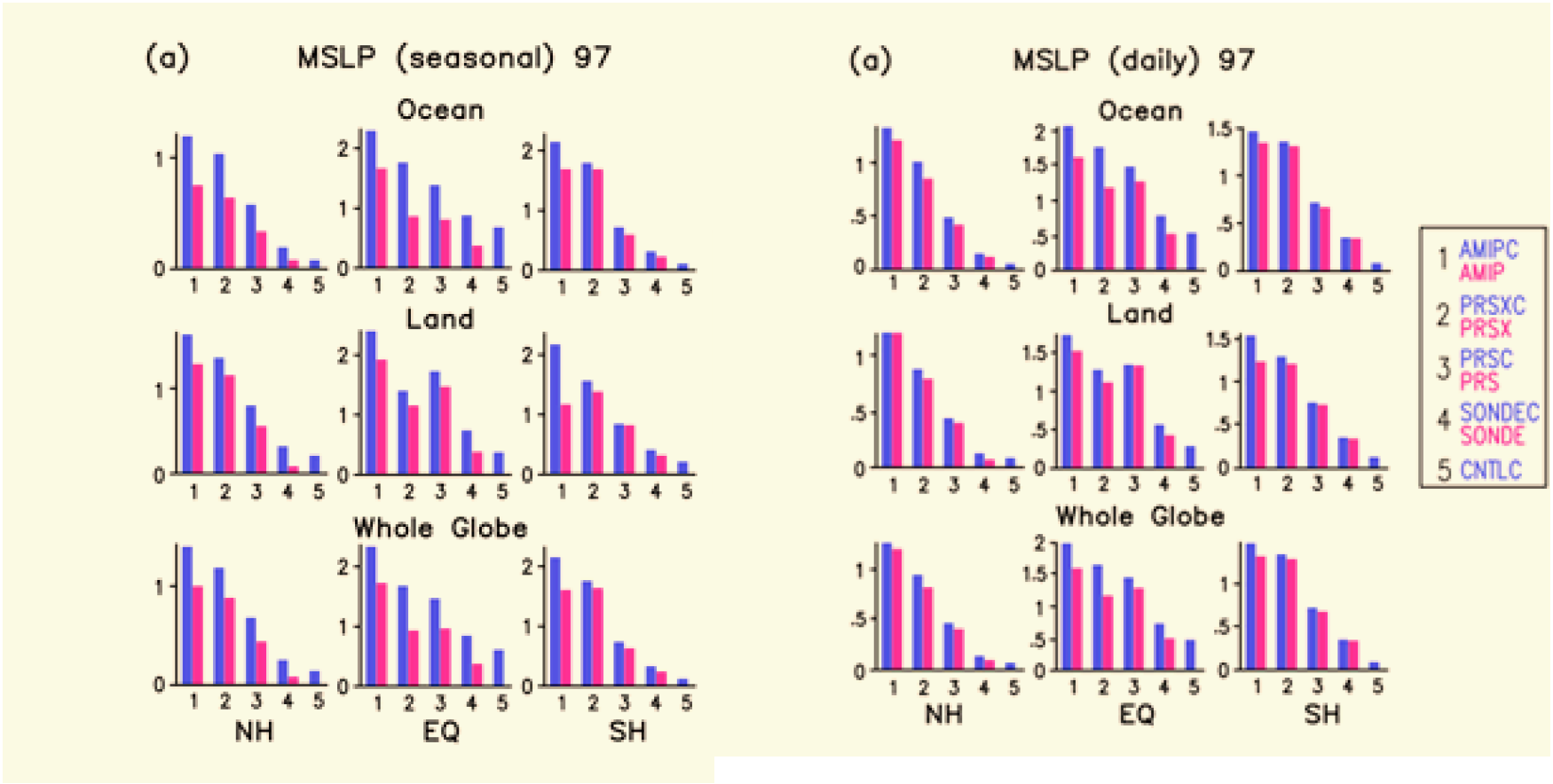

(b) 500Z (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH

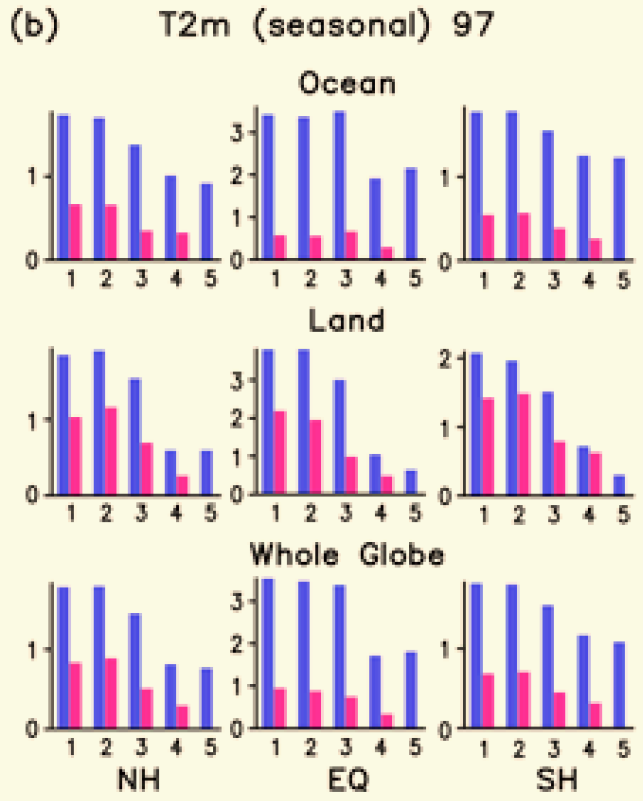
Daily Z500 RMSD

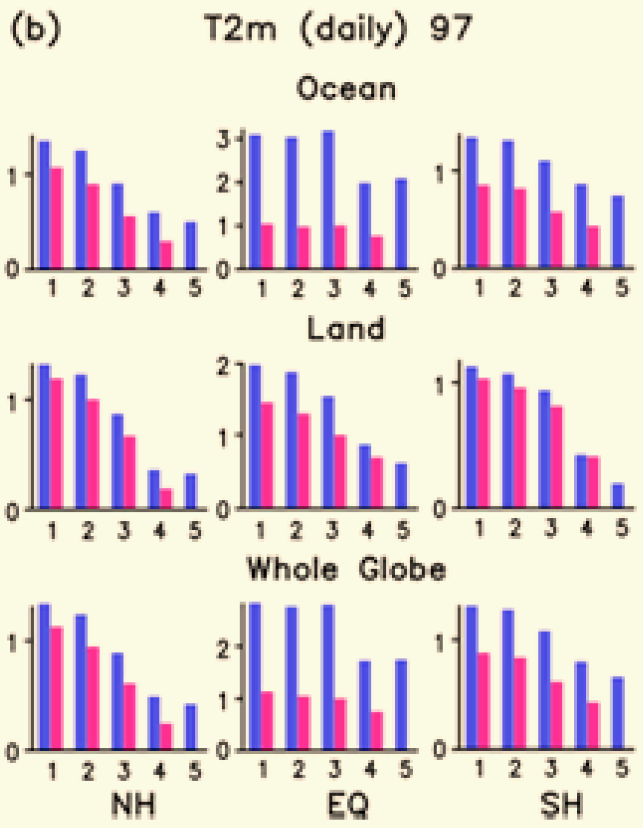
	NH	EQ	SH
AMIPC	120.	63.	115.
AMIP	111.	27.	98.
PRSXC	105.	57.	108.
PRSX	91.	21.	101.
PRSC	63.	40.	66.
PRS	49.	16.	55.
SONDEC	12.	9.	35.
SONDE	11.	7.	32.
CNTLC	4.	7.	6.

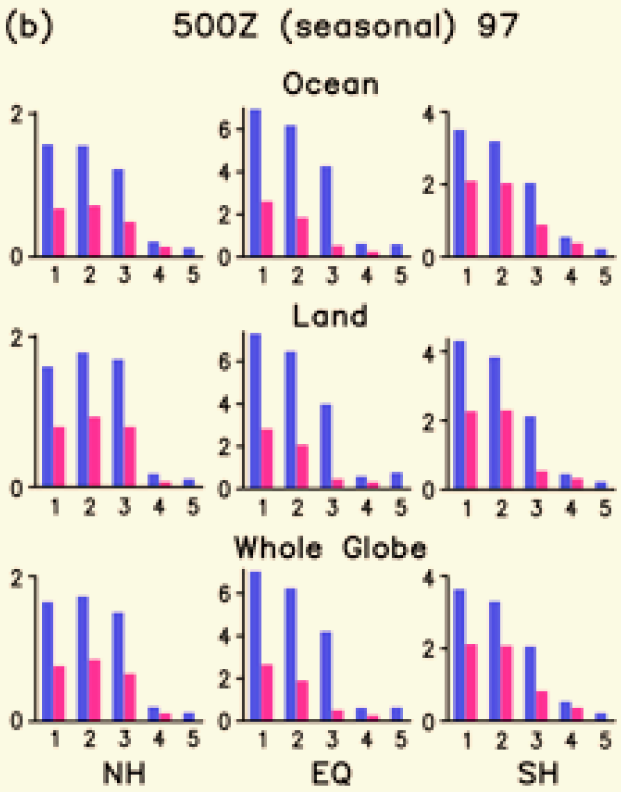
Whitaker et al.
~ 40 meter.

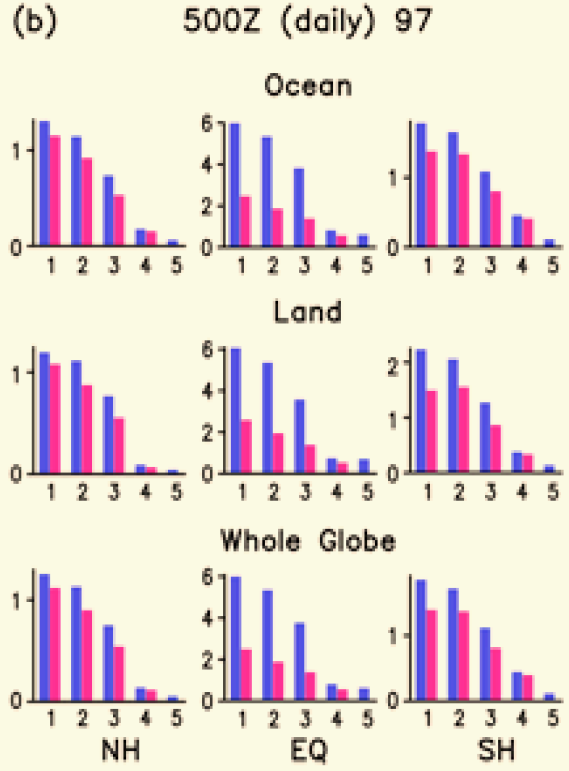
Seasonal RMSD


(a) MSLP (seasonal) 97
Ocean
Land
Whole Globe
NH
EQ
SH
(a) MSLP (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH
1 AMIPC AMIP
2 PRSXC PRSX
3 PRSC PRS
4 SONDEC SONDE
5 CNTLC


(b) T2m (seasonal) 97
Ocean
Land
Whole Globe
NH
EQ
SH


(b) T2m (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH


(b) 500Z (seasonal) 97
Ocean
Land
Whole Globe
NH
EQ
SH


(b) 500Z (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH

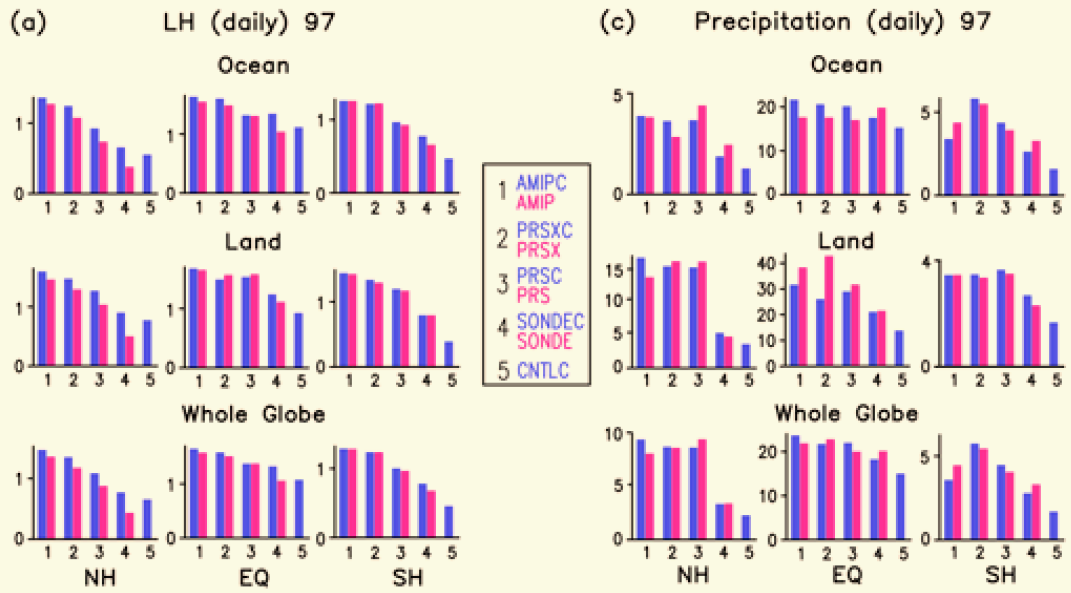
Seasonal Z500 RMSD

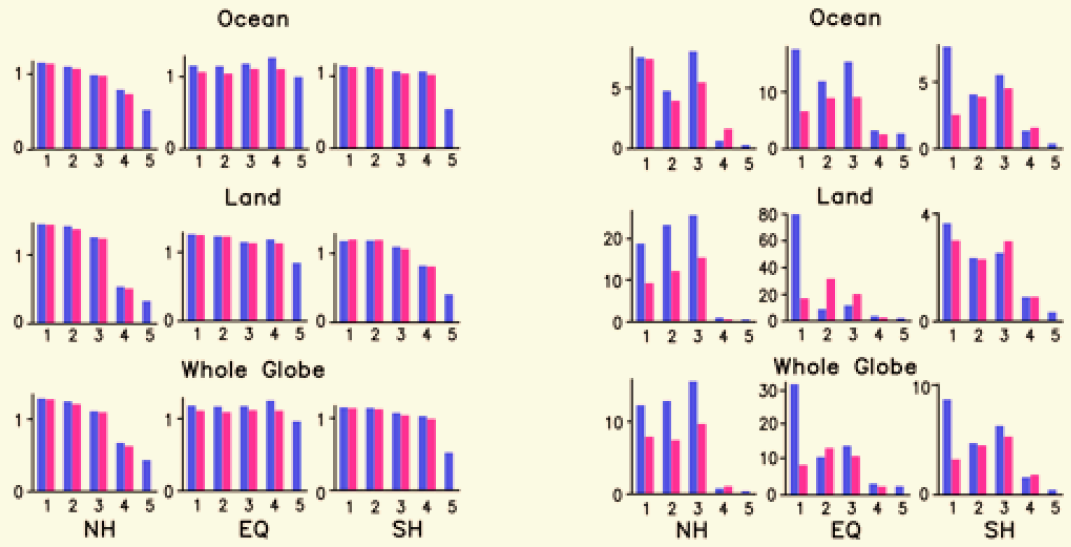
Seasonal	NH	EQ	SH
AMIPC	50.	61.	74.
AMIP	24.	23.	48.
PRSXC	51.	55.	66.
PRSX	32.	17.	54.
PRSC	44.	38.	40.
PRS	24.	6.	22.
SONDEC	6.	7.	15.
SONDE	5.	3.	11.
CNTLC	3.	6.	4.

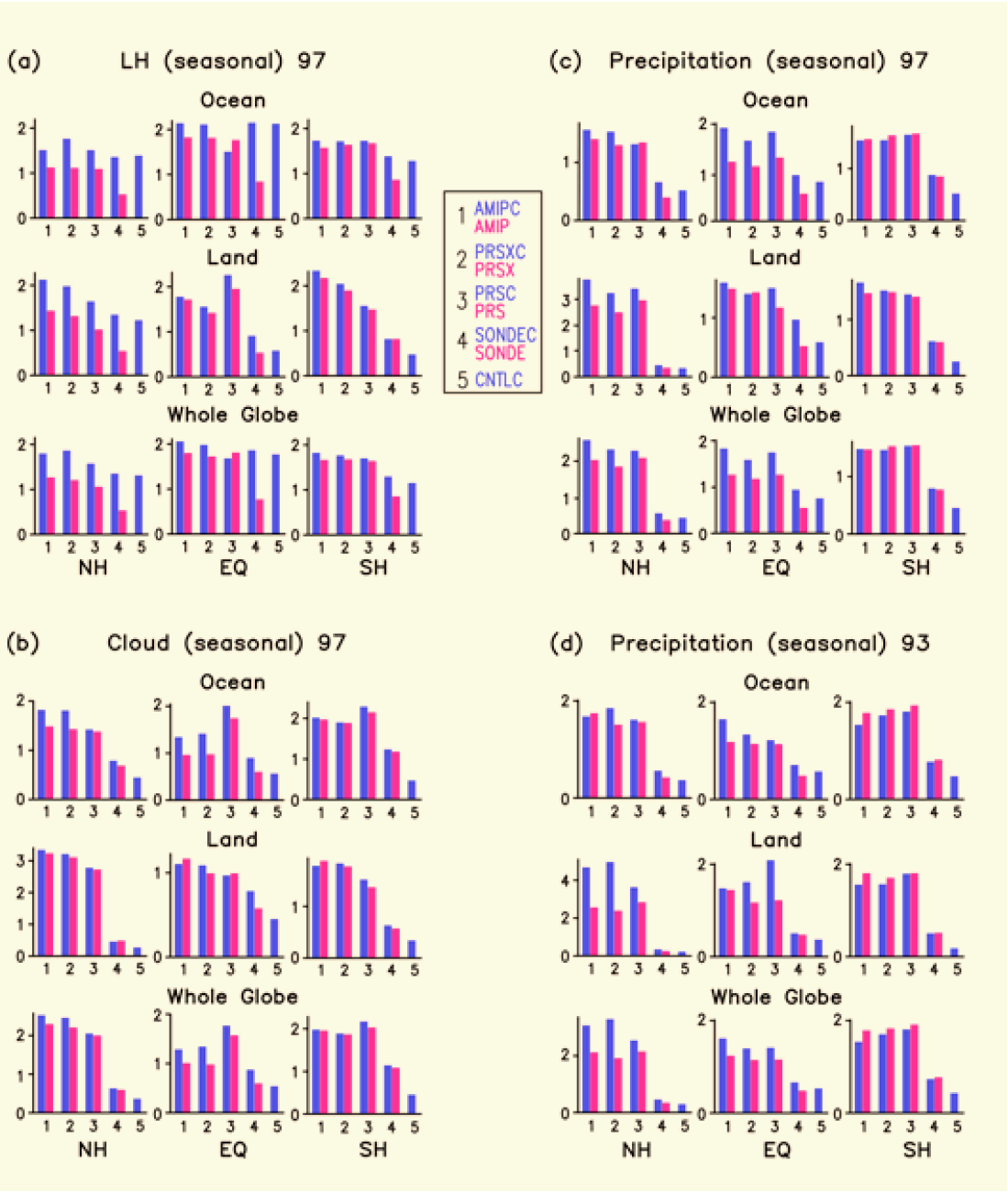
Daily	NH	EQ	SH
AMIPC	120.	63.	115.
AMIP	111.	27.	98.
PRSXC	105.	57.	108.
PRSX	91.	21.	101.
PRSC	63.	40.	66.
PRS	49.	16.	55.
SONDEC	12.	9.	35.
SONDE	11.	7.	32.
CNTLC	4.	7.	6.

Bengtsson et al.
~ 25 meter.

Impact on diagnostics fields


(a) LH (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH
1 AMIPC AMIP
2 PRSXC PRSX
3 PRSC PRS
4 SONDEC SONDE
5 CNTLC
(c) Precipitation (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH


(b) Cloud (daily) 97
Ocean
Land
Whole Globe
NH
EQ
SH
(d) Precipitation (daily) 93
Ocean
Land
Whole Globe
NH
EQ
SH


(a) LH (seasonal) 97
Ocean
Land
Whole Globe
NH
EQ
SH
1 AMIPC AMIP
2 PRSXC PRSX
3 PRSC PRS
4 SONDEC SONDE
5 CNTLC
(c) Precipitation (seasonal) 97
(b) Cloud (seasonal) 97
(d) Precipitation (seasonal) 93

Summary of the impact of SST, Ps and Sonde observation in N.H.

	Sea Surface Temp		Surface Pressure		Sondes	
Analysis vrbl	Daily	Seasonal	Daily	Seasonal	Daily	Seasonal
T2m	++	++	+	+	++	++
Ps	+	+	++	+	++	++
Z500	+	++	++	+	++	++
LHF	+	+	+	0	++	++
CLD	+	+	+	0	++	++
Precip	+	+	0	0	++	++

Conclusions (1)

- The impacts of observation and SST are different for different time scales. SST, which has long time scale, tends to have greater impact on long time scale analysis, while daily surface pressure observation tends to impact more on daily analysis.

- The NCEP SSI seems to filter out long time scale information from surface pressure observation. We encourage research to understand the filtering characteristics of objective analysis schemes.

Conclusions (2)

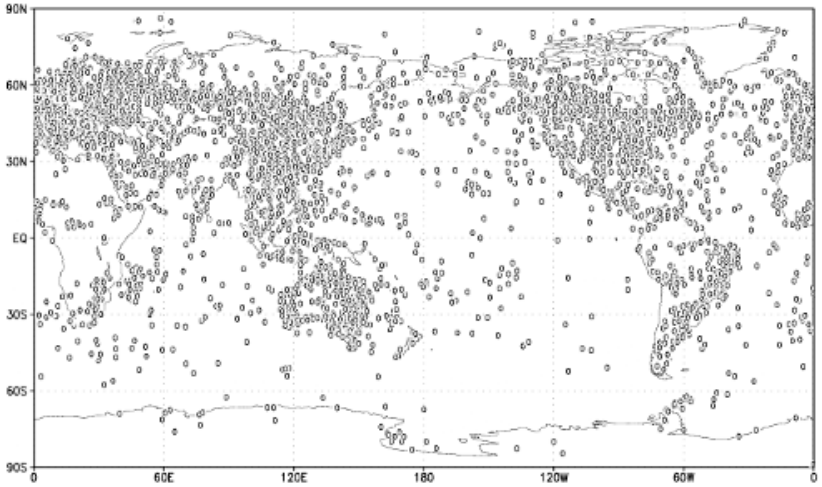
- Surface pressure observation is important for high frequency (daily) analysis of surface pressure and free atmospheric geopotential height. It also has positive impact on daily scale latent heat and cloudiness diagnosed from model. The impact on precipitation is small, but this can be strongly model dependent.

Conclusions (3)

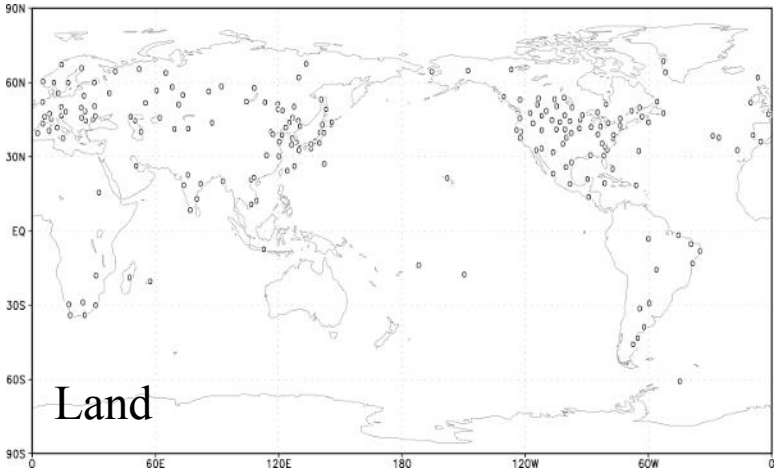
- SST is important for diagnostic fields, such as the surface fluxes and precipitation.
- Inferior SST analysis will contaminates the good atmospheric analysis even over land.
- For more accurate analysis, radiosonde observation is indispensable.

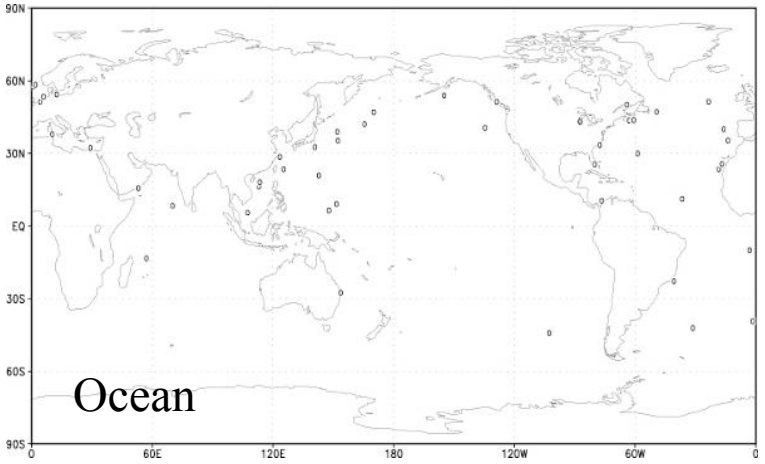
END

Full observation distribution. 00UTC Nov. 7, 1997

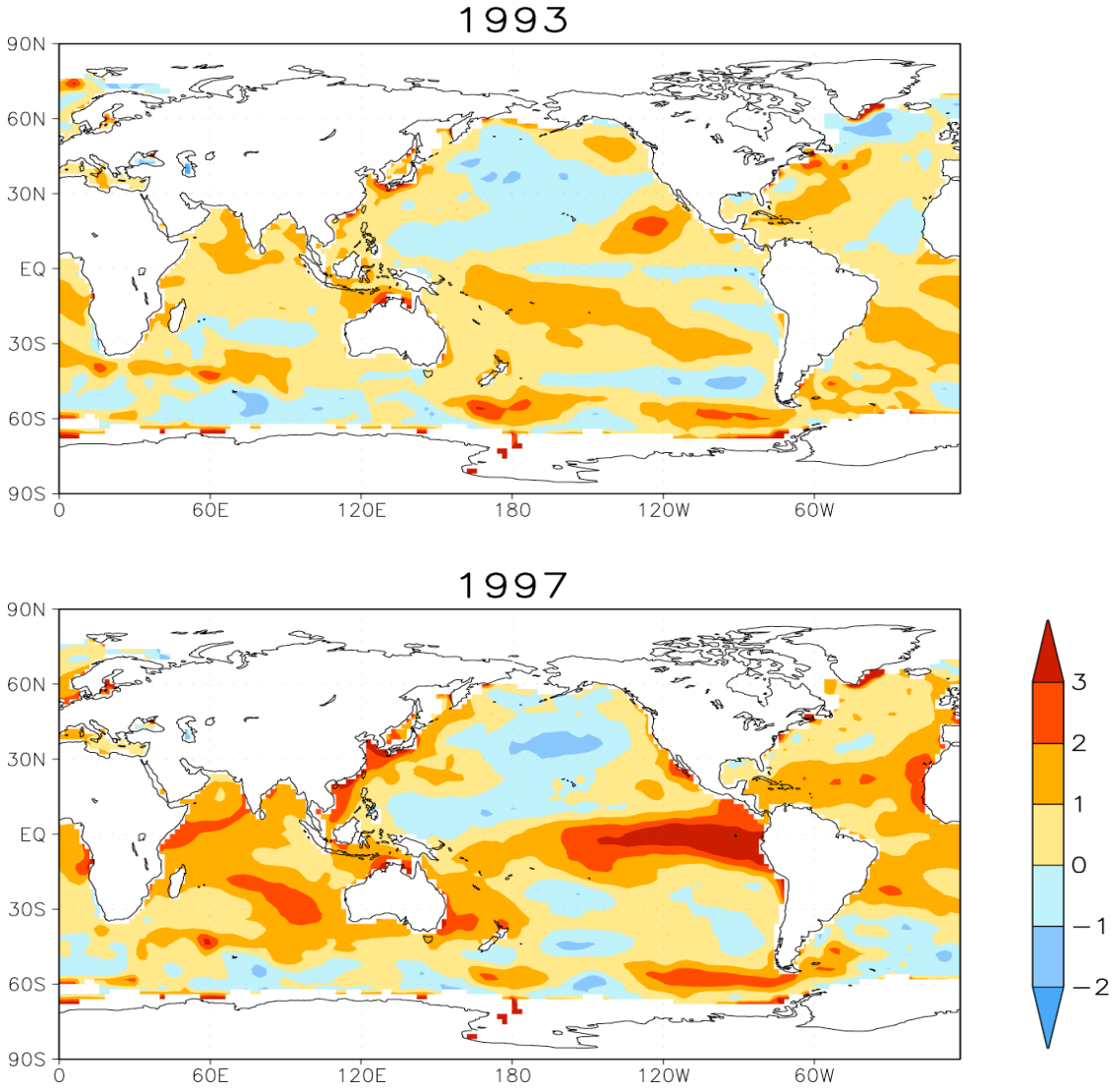


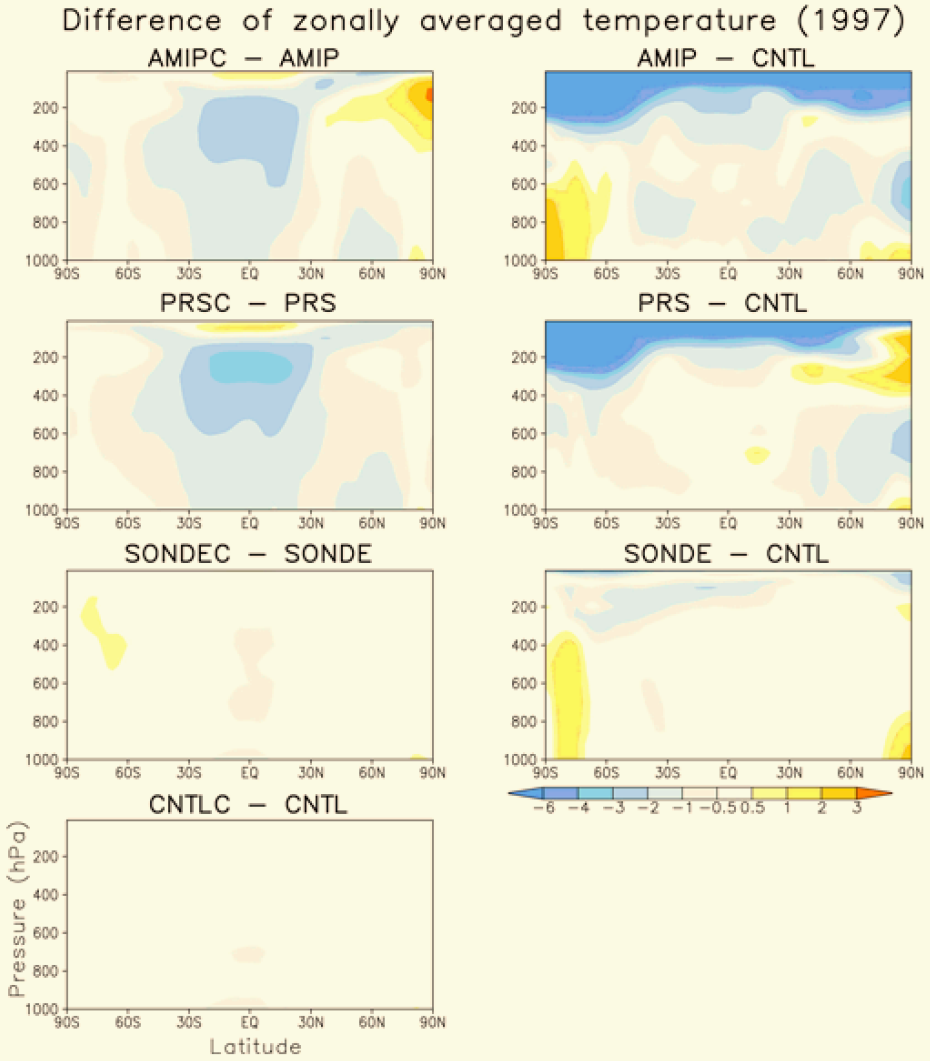
Simulated Ps observation distribution for 1915

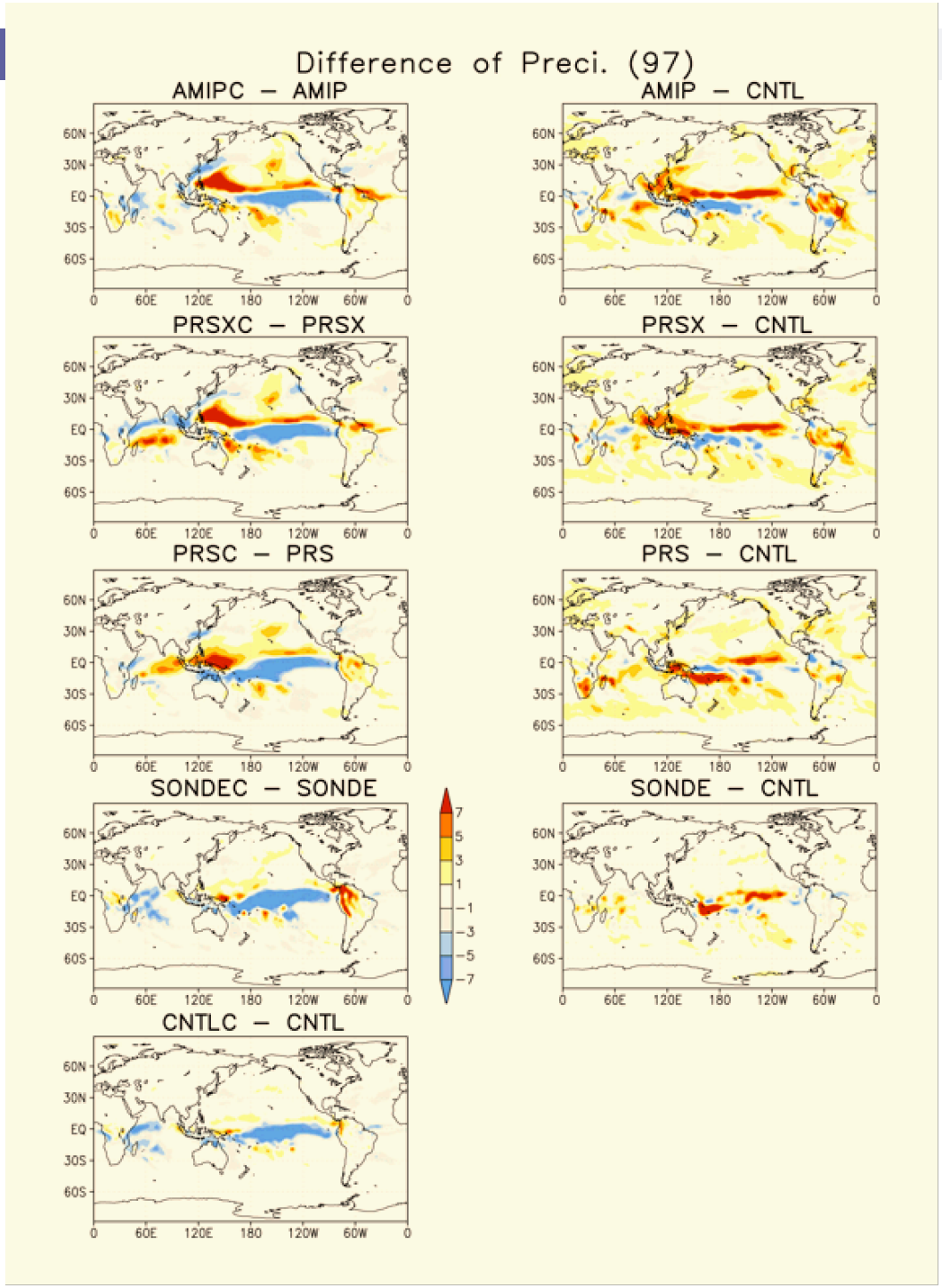


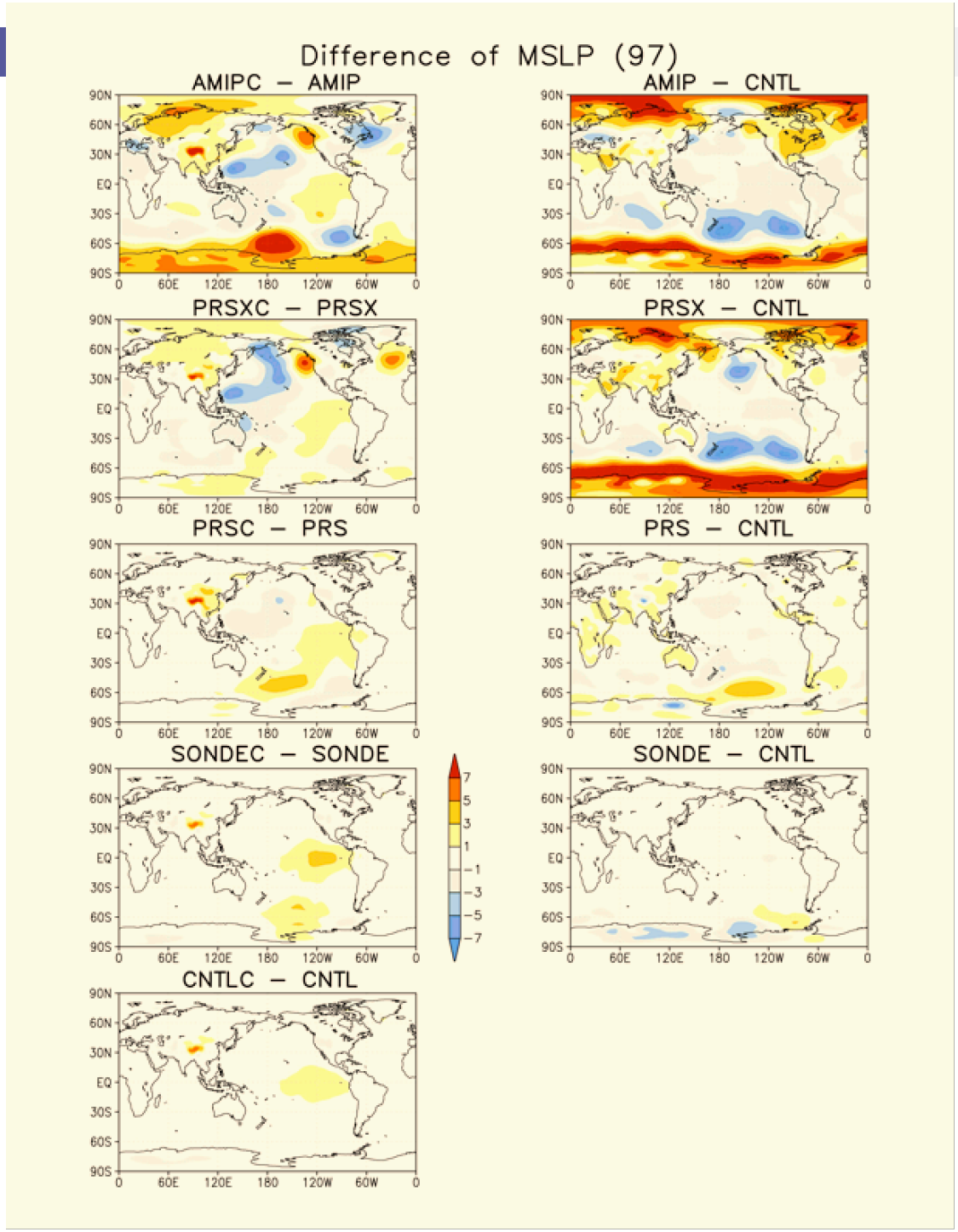


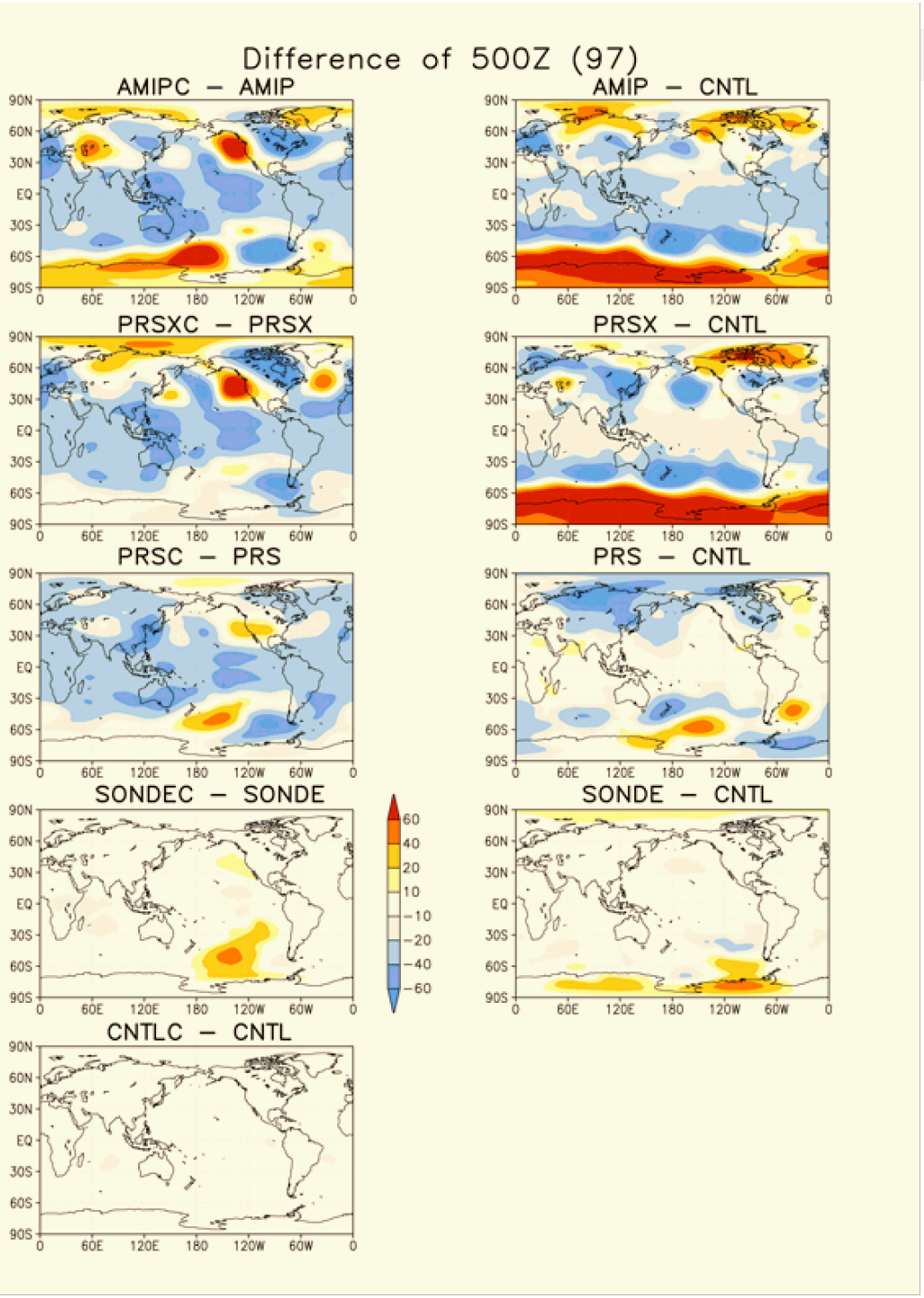
Analyzed SST – Climatology SST




Difference of zonally averaged temperature (1997)
AMIPC – AMIP
AMIP – CNTL
PRSC – PRS
PRS – CNTL
SONDEC – SONDE
SONDE – CNTL
CNTLC – CNTL
Pressure (hPa)
200
400
600
800
1000
90S
60S
30S
EQ
30N
60N
90N
Latitude
−6 −4 −3 −2 −1 −0.5 0.5 1 2 3

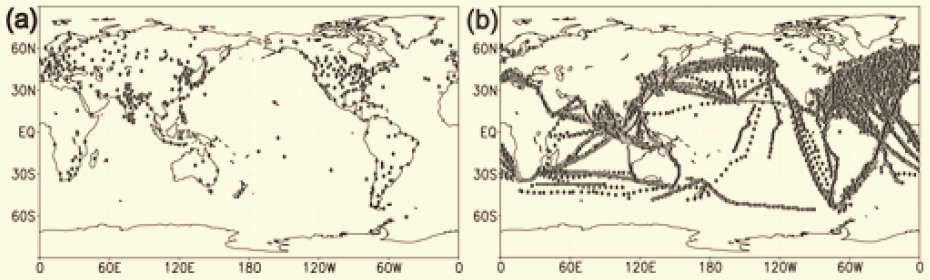

Difference of Preci. (97)
AMIPC – AMIP
AMIP – CNTL
PRSXC – PRSX
PRSX – CNTL
PRSC – PRS
PRS – CNTL
SONDEC – SONDE
SONDE – CNTL
CNTLC – CNTL
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
7
5
3
1
−1
−3
−5
−7


Difference of MSLP (97)
AMIPC – AMIP
AMIP – CNTL
PRSXC – PRSX
PRSX – CNTL
PRSC – PRS
PRS – CNTL
SONDEC – SONDE
SONDE – CNTL
CNTLC – CNTL
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
7
5
3
1
−1
−3
−5
−7


Difference of 500Z (97)
AMIPC – AMIP
AMIP – CNTL
PRSXC – PRSX
PRSX – CNTL
PRSC – PRS
PRS – CNTL
SONDEC – SONDE
SONDE – CNTL
CNTLC – CNTL
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
60
40
20
10
-10
-20
-40
-60

Simplified ensemble data assimilation

- Simply perform ensemble data assimilation by perturbing the very first analysis guess field.
  - 5 member analysis
  - Ensemble mean of daily analysis
- Runs without observation (AMIP) is also made in ensemble mode.


(a)
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
(b)
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0

Ensemble Assimilation